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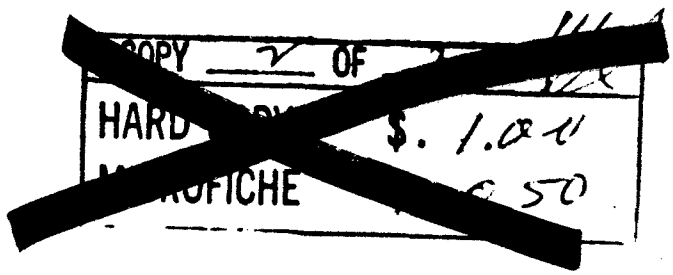

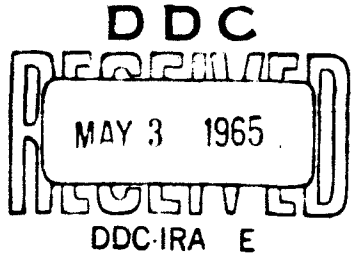

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SOME COST ACCOUNTING PROBLEMS IN PERT COST

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As originated in 1958, PERT may be viewed as a natural evolution in the "systems" approach to management problems. It provided a technique for regarding an organization as the entity which it is: an integrated assembly of interacting elements designed to achieve a predetermined goal.

As first applied, however, PERT was oriented only toward scheduling problems. As the PERT Time system became established, the Department of Defense undertook the design and development of the cost aspect of PERT. A document was issued in June, 1962, as a uniform approach to PERT Cost management under the joint aegis of the Department of Defense and the National Aeronautics and Space Administration. The manual, entitled DOD and NASA Guide - PERT Cost System Design, was based on several limited-scale pilot tests on research and development projects.

PERT Cost is an extension of the PERT approach. In the PERT Cost system, the overall program is divided into successively smaller pieces of prime hardware, support equipment, facilities, and services for costing purposes. Estimates are made of manpower, material, and other resources necessary to perform groups of activities referred to as work packages. These are then converted to dollars. The original estimates are compared to actual costs on a periodic basis. In brief, PERT Cost seeks to integrate time and cost considerations on a common framework.

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PERT Cost provides the means by which information is provided in the varying levels of detail as needed for evaluation of schedule and cost performance and for the prediction and control of time and cost variances. Among the advantages claimed for PERT Cost is that it not only permits more accurate measurement of progress but also enables managers to appraise, more realistically, the relationships of accumulated and projected costs of the program. In addition, the expectation is that PERT Cost will provide time and cost data for decision-makers weighing alternative courses of action.

The focus of this Paper is on a general category of cost accumulation problems affecting the operation of the PERT Cost system. These cost accounting considerations are based on findings derived from field investigations in several companies during early attempts to implement the system.

It should be remembered that some of these difficulties are inherent in more traditional cost accumulation systems, while others are partly peculiar to PERT Cost with its requisites for increased detail for end items. No attempt has been made to arrange the problems in order of probable significance, since such a comparative measure is largely indeterminate at this time.

DIRECT LABOR

The number of work orders (or counterparts) required for PERT Cost obviously exceeds that of prior cost control techniques. The establishment of an expanded work order pattern is no problem. However, it is often difficult to obtain the full cooperation of employees in charging to correct work orders. The finer the breakdown, the less accurate the charging activity is likely to be. The tendency of an employee to charge to a few, rather than many, work orders could distort the PERT Cost reporting system. Constant training of personnel plus continual monitoring can minimize, but not completely eliminate, inaccurate charging. This problem should be given adequate consideration in determination of detail and number of work orders to be established.

Because of the amount of detail in PERT Cost, conversion of forecasted direct labor hours into direct labor costs and applicable overhead could potentially be a major clerical task on a large development program. The computations, however, can be spread over a time horizon for various work packages through use of a computer.

The application of direct labor rates in conversion from hours to dollars may be troublesome in some companies. This is because accounting records at the lowest functional level in PERT Cost usually incorporate either the actual direct labor rate paid to the employees or an average actual of a section or department. On the other hand, for budgetary purposes, grossly estimated and aggregated direct labor rates may normally be used for such levels. Thus, PERT Cost could indicate one condition based on a forecasted rate, while reported costs based on actual rates would reveal a contrary result.

Such a problem would simply stem from the fact that direct labor rates are not normally recorded, budgeted, and forecast on the same basis. One solution is to establish control at the lower levels in direct hours only. The other possibility, obviously, would be to expand the projection of labor rates to include the lowest levels in the organization. The cost of such an effort, however, might be prohibitive.

The PERT system does not at present provide for distinguishing variances due to direct labor rates from direct labor hour performance. Special reports, however, can be prepared for this purpose.

RAW MATERIALS

One of the accounting problems in PERT Cost for which an easy solution does not appear entirely evident at this time is in the materials area. For discussion purposes, the term "material" is defined to include such items as raw materials, purchased parts, and electrical and mechanical equipment. Type and quantity of raw material are usually determined from engineering drawings and translated into a bill of material. Material may then be classified as to types and summary schedules prepared for each classification. Purchase orders can then

be placed for the total amount of anticipated material requirements with provision for scrappage, loss, breakage, and other attrition factors. This method is employed to obtain price advantages and to insure the availability of all materials as needed.

When raw materials and purchased parts were received for inventory in one of the first PERT Cost applications, they were costed against special PERT Cost control codes established for material charges only. These categories were in accordance with a material classification maintained by type of material -- for example, purchased electrical and mechanical equipment. A procedure was not available whereby such costs could be identified to end item either as received or as consumed.

Accumulation of costs was accomplished through use of a serial number coding system shown as follows:

Work Order	Ship Lot	Component Identification Number	Materials Group
XXX-XX-XXX	XXX	XXX	XX

Material was charged to the same work order as was used for labor charges.

Establishment of separate work packages for materials was not intended in the initial PERT Cost guides and manuals. The original approach offered, rather, was to allocate and prorate material costs to all work packages where material may be required. The materials problem in PERT Cost is now recognized, although not yet conclusively resolved.

The case often cited against allocation of material costs to a work package, as a control technique, may be illustrated as follows: Assume that six identical units are required on an aircraft. Two units are to be installed in the fuselage and two in each wing. If nine units were actually used in the airplane, because of excessive usage, the contention is that the allocation method would cloud or perhaps minimize the difficulty by prorating the excess cost of one unit to the fuselage and one to each wing.

The basic argument is that a control technique should be designed to indicate the cost of the excess usage and price variances and to

identify to functional responsibility, that is, engineering, manufacturing, et cetera, and subdivisions thereof. The knowledge that excess usage has occurred is in itself useless. Only when sufficient data relative to the variance have been transmitted to management can action be taken to correct the condition.

The establishment of work packages into material groups, it is claimed, also facilitates the preparation of budgets and cost-to-complete forecasts by classes of material and the identification of problem areas. Once a variance is identified, according to this rationale, the cause can be traced through other procurement and material accounting control systems.

All of these control advantages can be obtained, however, using the existing system, and still transfer charges from the materials control accounts to individual end-item work packages as the materials are consumed. In the absence of such a step, total costs by end item are not available unless special reports are developed.

Two dichotomous definitions can be established for the term, "actual material costs." These are (1) costs including commitments, and (2) only those costs included in the accounting records. The PERT Cost system must predict material variances far enough in advance for any necessary corrective action to be taken.

The time span between engineering release of the material and utilization of material in fabrication is lengthy in many instances. As shown in Fig. 1, this time period may be somewhat more than a year in certain types of manufacturing.

Material can be assigned to an appropriate work package at the time the purchase order is placed. Then the commitment could be considered a part of the actual cost incurred. Under this procedure, special provision must be made to account for the value of inventory not supplied from purchase orders (but rather from surplus inventory other contracts, et cetera), because such material would not be entered into the system until actual requisitions were prepared for transfer from inventory to work-in-process.

The prime advantage claimed for assigning committed costs to work packages is that this procedure facilitates forecasting, since

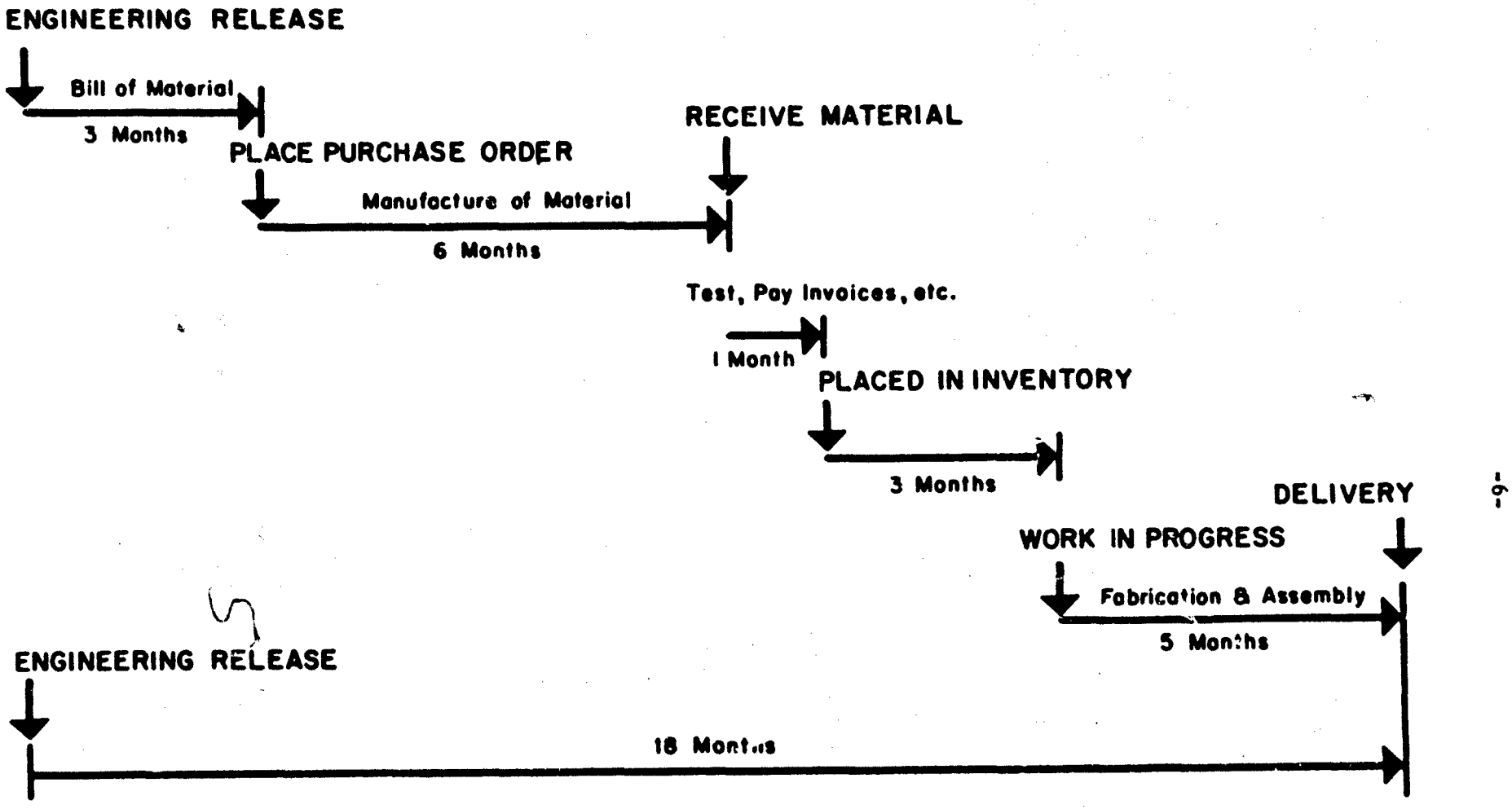

Fig. 1 - Material Lead Time

a forecast of the time a purchase order will be placed may be more reliable than the prediction of the time that a material vendor will submit invoices as indicated in Fig. 1. Among the disadvantages is the fact that an additional set of records are required to provide data for cash flow and other essential financial needs for the company and customer, outside the PERT Cost area.

Another solution is to record the cost of material at the time the invoices are paid. As already noted, this introduces complexities to the process. However, here the accounting records would show only incurred costs. Therefore, one set of cost expenditures would be published and PERT data could be utilized in projecting the company's cash position. An extension of this approach would be to include the identification of incurred cost at the work package level when material entered the inventory. Thus, variances could be identified prior to entering work-in-process.

A policy to include only actual costs in the PERT system does not preclude the possibility for identification of material price variances at the time of commitment. Where committed costs are not shown in the accounting records, the data can be obtained through use of normal commitment accounting procedures maintained by many companies. The commitment data can then be incorporated into cost-to-complete records for control purposes with only "true" costs incorporated into the PERT system. In general, this approach on balance may be more advantageous in many instances than the alternative of forecasting the time period in which commitments will become actual costs in the accounting records.

LEVEL OF DETAIL AND DURATION OF WORK PACKAGES

One of the most significant contributions of the PERT Cost system will be a considerably more detailed breakdown of estimated and actual costs for individual components or end items of an overall program. Frequently, it has been stated that it is not advisable to subdivide the coding structure more finely than practical for collection of actual costs. However, this guideline is somewhat less a limitation

today than in the past because automation of accounting functions has made more detailed cost collection feasible.

The level of detail which is desirable is largely a matter of judgment and will vary from project to project. The depth of the work breakdown will differ on each program depending on such considerations as the complexity, length, and cost of the program, subcontracting relationships, the company's organizational structure, and its traditional approach to management controls. The significance of an individual expense item to the total component also is an appropriate criterion for determination of whether it should be included in a breakout. Additionally, all functional responsibilities in a company do not subdivide their work to a common level. Each organization tends to seek its own practical level.

Needless to say, all information which is accumulated should not be transmitted to higher management levels. On the other hand, for analytical purposes, considerable detail is required. In designing the various PERT Cost reports, an attempt has been made to recognize these differing requirements for information.

Once the end-item orientation has been achieved, there is another equally important aspect of level of detail. In theory, it should be possible to divide the work to be performed on each end item into a series of individually identifiable steps or sub-phases and to associate resource requirements with each of these steps. It was such reasoning that prompted the developers of the PERT Cost system to suggest originally that work packages should be of approximately three months duration, as well as represent a dollar requirement no greater than $100,000. Such short-duration work packages are necessary to attain the full potential of PERT Cost as a predictive and control tool.

In this context, such short term, discrete work packages did exist on one of the first major applications of the PERT Cost system. However, as was the case with predecessor systems, the work program was further subdivided into small increments through the use of a work-order numbering system in engineering and serialized shop traveler orders in manufacturing. Such breakdowns are used as a basis

for budgeting, collecting actual manpower, and identifying variances for specific jobs performed.

Exactly how these localized controls relate to the overall management reporting, which is the aim of PERT Cost, is not entirely apparent today. However, the small packages are not necessarily integrated with respect to time and cost on an overall basis. Moreover, the work-order type of approach is oriented primarily toward short term control, and probably does not provide an adequate basis for long term prediction.

The method by which a company may attempt to determine percentage of work completed still would vary with functional responsibility. Control resides in systems that have existed prior to PERT Cost -- for example, production control procedures in manufacturing. These systems continue to contain all of the strengths and weaknesses they reflected in the past.

It is helpful in noting this time span problem, to review the points of view expressed during the early phases of implementation of the aforementioned application. The PERT administrators felt that it was very difficult if not impossible to delineate firm identifiable intermediate points after release of first drawings. Category I Flight Testing was cited as an example. Here a number of airplanes are to undergo a series of tests over a 2-1/2-year period. It was stated that the trials are not performed in any sequential pattern, the vagaries of the procedure depending on anything from weather to success of predecessor tests. Maintenance is one of the biggest elements of cost in this testing category. Yet, maintenance is not scheduled on a per aircraft basis, since such work is largely a function of the indeterminate flying program. Testing in take-off and landing would be the same for every airplane, even though the primary test will be for the first unit. Therefore, this item also would continue for the entire testing period which militates against the establishment of work packages with a short time span.

In this regard, however, it should be noted that the existence of a high degree of uncertainty in an operation should not preclude an attempt to establish system and order, that is, the scheduling and

estimating of resource requirements. Moreover, the optimum size of work packages may vary as a function of the specific details of a program and, perhaps, the organizational structure of a company.

One other point should be raised in connection with the subject of the appropriate time span for work packages. It well may be that it is necessary in PERT Cost, just as it is in many other cost accounting applications, to examine in detail the criteria to be used in distinguishing among direct, level-of-effort and indirect or overhead functions. In the conventional industrial manufacturing environment, functions which are considered to be direct are limited to those charges which can be associated directly with individual units emerging from the manufacturing process. Costs for such functions would vary proportionately with quantity produced. All other functions, whether fixed in size or indirectly variable with production quantity, are considered to be a form of overhead. In the aerospace industry, however, where various forms of cost reimbursable contracts have become traditional for much major development work, and burden rates have been the subject of frequent negotiation, it has become general practice to isolate as many staff and support-type functions as possible as separate line items so that they may be charged to the customer on a direct cost basis. In addition, this practice has been furthered in those instances when the customer has directed that various types of staff functions -- for example, engineering for maintainability and quality assurance -- be incorporated. In such instance a special effort has been made to prepare separate estimates and maintain records of actual charges for these items.

Since many staff or support-type functions originally were authorized on a level-of-effort basis, often to extend throughout program life, they do present certain problems to those charged with developing a work breakdown structure. Therefore, it probably is necessary to recognize that there really are significant functions not directly associable with end items, that is, of an overhead type, which must be identified on a direct cost basis, especially in the defense industries.

It is appropriate here to mention briefly the alternative methods which can be considered for treating these "overhead-type" level-of-effort functions where they present problems. The simplest method is merely preparing a single work package extending through total program life for each of these categories. This would appear to be the approach currently utilized in the case noted previously.

On the other hand, if identification of all estimated and actual costs to end item were the primary objective, the cost of each direct level-of-effort function should be handled in the same fashion as overhead, that is, prorated to direct end sub-items or tasks.

A third possible treatment would be to prepare a series of short duration level-of-effort packages -- for example, one to three months -- which when grouped sequentially would extend throughout the life of the program. Such a treatment, though limited in predictive value, probably would facilitate control.

CONTROL OF OVERHEAD

Overhead is reported as a single line item in PERT Cost and overhead activities are usually not included in the network. Yet, burden costs are conventionally about equal to labor expense in many companies.

A first step toward better control of overhead might be an expansion within the PERT Cost reporting framework of the overhead line item into its basic categories, such as indirect labor, operating supplies, and so on. Because of the differences in definition and allocation of overhead by various contractors, it is all the more necessary that indirect costs should be included. Indirect charges are no less contributory to overruns than direct costs.

SUBCONTRACTS

Since subcontract items may constitute an important portion of some programs, they are an important consideration in PERT Cost. The subcontractor or subsystem costs can usually be handled relatively simply in the work breakdown structure. The subsystem represents

either a part or the total cost of an end item in the work breakdown structure, for instance, an attack radar. The single end item can be broken down into end sub-items and work packages of the subcontractor's accounting system. Cost data can then be fed into the prime contractor's PERT Cost system.

A preliminary instructional handbook for subcontractors, based on the Air Force and DOD/NASA PERT Cost guides, was issued by one prime contractor early in the program. In this manual it was suggested that the subcontractor maintain at least one level of breakdown below that level required by the prime contractor for reporting purposes. Below this, the level should be determined by the subcontractor's management requirements. The statement was made that the "ultimate goal should be to achieve a sub-division of task that will represent manageable units for planning and control purposes." It also was indicated that flexibility should be built into the PERT Cost system, so that more detail could be made available to the prime contractor in cases of significant cost variances.

GENERAL AND ADMINISTRATIVE COSTS AND FEE

General and administrative costs (G&A), that is, corporate level burden, should be included in the PERT Cost system at least at the summary level. In some cases the contractor may elect to include G&A also at the work package level. Here again, the inclusion of one line item only in the report sheds little light on the ingredients of such a charge. However, in this case it may not be significant, because G&A costs usually are minor compared to other overhead expenses.

Fee clearly should be included at least at the total contract level. Inclusion of fee does add an additional complexity to the system, particularly when an incentive-type contract using a sliding scale for the fee which is allowable is incorporated. The investigation of such implications is beyond the scope of this Paper but would make an appropriate topic for further research.

SOME GENERALIZATIONS AND CONCLUSIONS

The implementation of PERT Cost inevitably should result in more complexities than many prior management control systems, since the attempt is to relate both network modeling and cost considerations to complicated programs.* Generally, however, the price of progress is some degree of inconvenience or adjustment. Current editions of published manuals on PERT Cost represent the normative approach to system design. With respect to accounting, the better policy -- and that followed in defense applications -- is to cause a minimum disruption to existing procedures when PERT Cost is installed for the first time.

Many of the problem areas noted in this Paper are not indigenous to PERT Cost but rather existed prior to the application of advanced network modeling and costing techniques. For example, the treatment of commitments and cost control for overhead have always been troublesome in accounting applications. However, the handling of materials costing and breakdown of the work program into increments of small time and cost duration have presented unique difficulties in initial implementations of the PERT Cost procedure. These, and other, problems may well be resolved as more and more experience is gained with the system, particularly in a diversity of applications.

Many observers believe that the integrated planning features of PERT Cost alone more than justify the installation of the system. At minimum, PERT Cost should result in improvements in cost control through an ability to predict potential overruns and underruns in advance. The system also appears to provide a better method for cost estimating than predecessor approaches because of the increase in the amount of end-product detail and the more careful relating of the work breakdown structure to details of the task. Moreover, the end-product historical data will furnish a statistical source of invaluable usefulness in the costing of contemporary and, especially, future products. In the final analysis, PERT Cost has achieved remarkable acceptance in a short time and has already fulfilled many of its intended goals.

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*See L. S. Hill, Some Possible Pitfalls in the Design and Use of PERT Networking, The RAND Corporation, P-3038, January 1965, for a companion Paper on network modeling.